U.S. Express Mail Label No. EL857532136US
System And Methods For Invalidation To Enable
Caching Of Dynamically Generated Content
Inventors: Wen-Syan Li et al.
Attorney: Ronald Coslick – 073303-0118
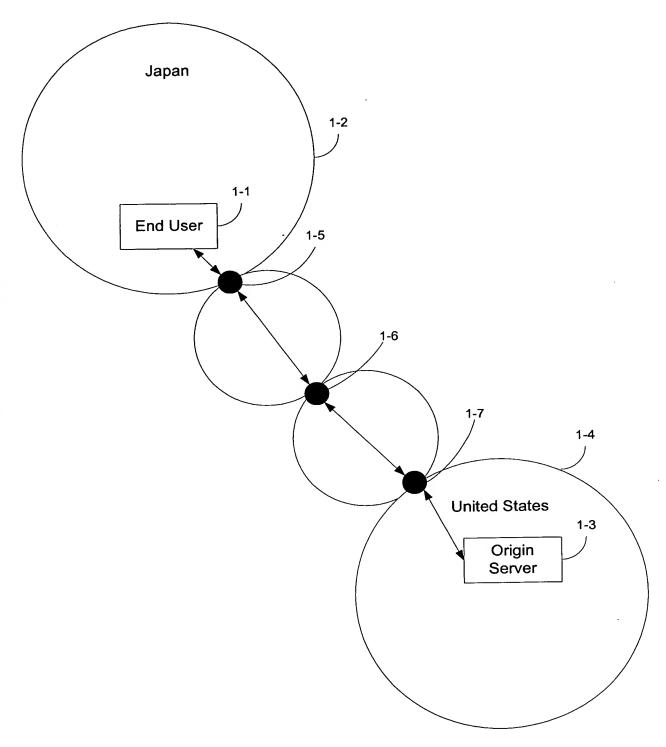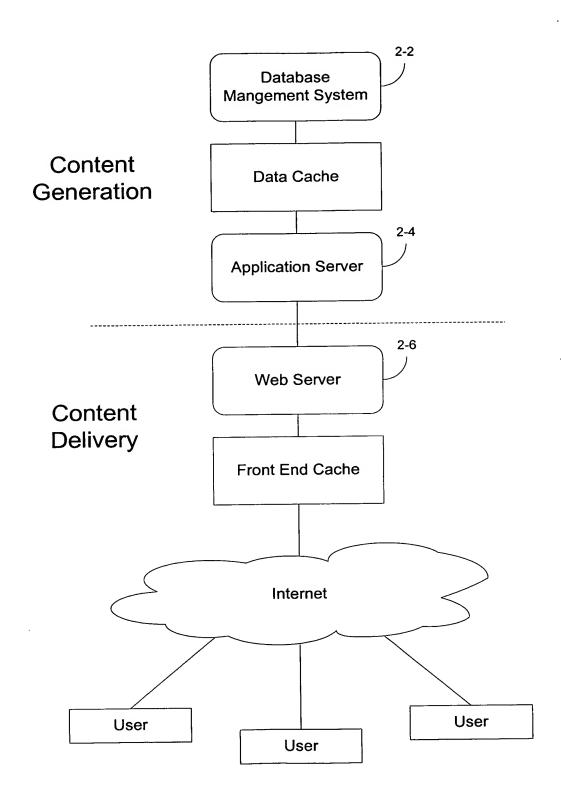FOLEY & LARDNER – (310) 277-2223
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Figure 1

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Figure 2

```
                          ┌──────────────────────┐  2-2
                          │      Database        │
                          │ Mangement System     │
                          └──────────────────────┘
                                    │
Content                   ┌──────────────────────┐
Generation                │     Data Cache       │
                          └──────────────────────┘
                                    │
                          ┌──────────────────────┐  2-4
                          │  Application Server   │
                          └──────────────────────┘
            - - - - - - - - - - - - - - - - - - - - - - - - - -
                          ┌──────────────────────┐  2-6
                          │     Web Server        │
                          └──────────────────────┘
Content                             │
Delivery                  ┌──────────────────────┐
                          │   Front End Cache     │
                          └──────────────────────┘
                                    │
                               (  Internet  )
                              /      │       \
                         ┌──────┐ ┌──────┐ ┌──────┐
                         │ User │ │ User │ │ User │
                         └──────┘ └──────┘ └──────┘
```

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System And Methods For Invalidation To Enable
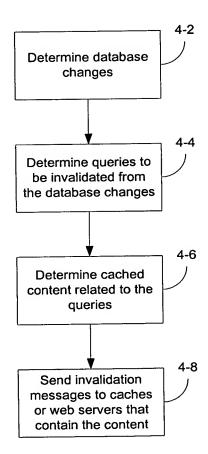Caching Of Dynamically Generated Content
Inventors: Wen-Syan Li et al.
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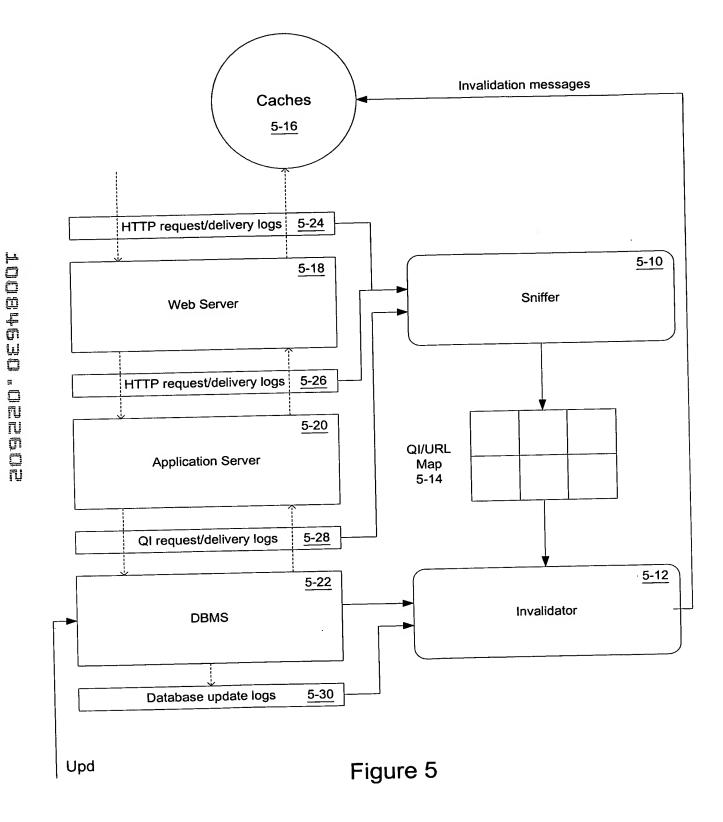FOLEY & LARDNER – (310) 277-2223
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Figure 3

Data ⟷ Queries ⟷ Content

Figure 4

```
                                    ┌─────────────────────┐  4-2
                                    │  Determine database │
                                    │      changes        │
                                    └─────────────────────┘
                                               │
                                               ▼
                                    ┌─────────────────────┐  4-4
                                    │  Determine queries  │
                                    │    to be invalidated│
                                    │  from the database  │
                                    │       changes       │
                                    └─────────────────────┘
                                               │
                                               ▼
                                    ┌─────────────────────┐  4-6
                                    │  Determine cached   │
                                    │ content related to  │
                                    │     the queries     │
                                    └─────────────────────┘
                                               │
                                               ▼
                                    ┌─────────────────────┐  4-8
                                    │  Send invalidation  │
                                    │ messages to caches  │
                                    │  or web servers that│
                                    │  contain the content│
                                    └─────────────────────┘
```

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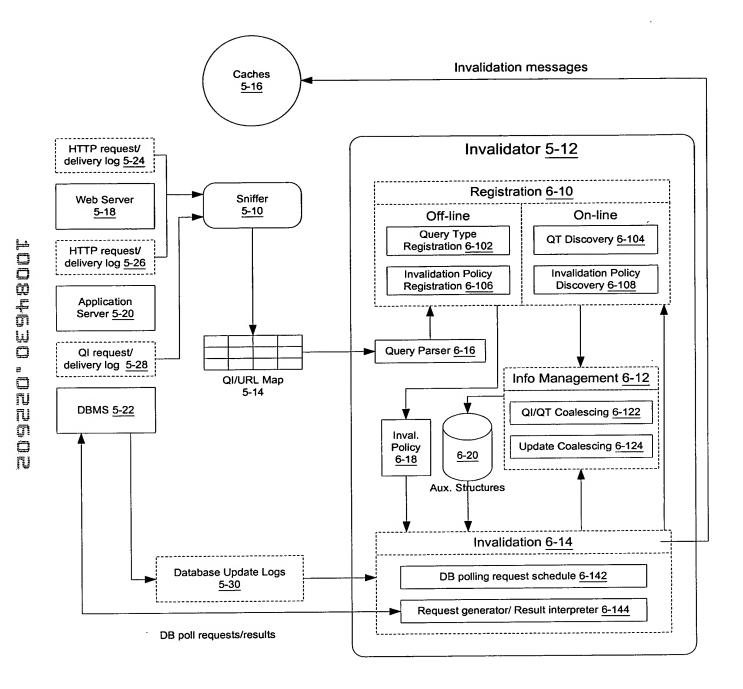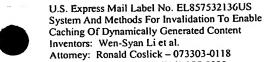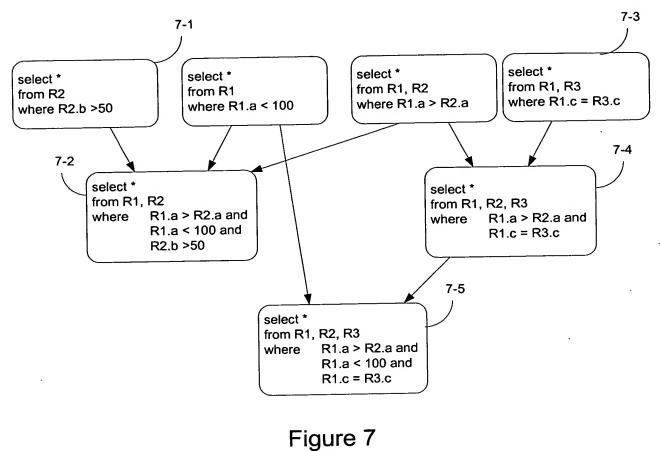FOLEY & LARDNER – (310) 277-2223
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Caches

5-16

Invalidation messages

HTTP request/delivery logs | 5-24

Web Server | 5-18

Sniffer | 5-10

HTTP request/delivery logs | 5-26

Application Server | 5-20

QI/URL
Map
5-14

QI request/delivery logs | 5-28

DBMS | 5-22

Invalidator | 5-12

Database update logs | 5-30

Upd

Figure 5

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Caches
5-16

Invalidation messages

HTTP request/
delivery log 5-24

Web Server
5-18

HTTP request/
delivery log 5-26

Application
Server 5-20

QI request/
delivery log 5-28

DBMS 5-22

Sniffer
5-10

QI/URL Map
5-14

Invalidator 5-12

Registration 6-10

Off-line

Query Type
Registration 6-102

Invalidation Policy
Registration 6-106

On-line

QT Discovery 6-104

Invalidation Policy
Discovery 6-108

Query Parser 6-16

Inval.
Policy
6-18

6-20

Aux. Structures

Info Management 6-12

QI/QT Coalescing 6-122

Update Coalescing 6-124

Database Update Logs
5-30

Invalidation 6-14

DB polling request schedule 6-142

Request generator/ Result interpreter 6-144
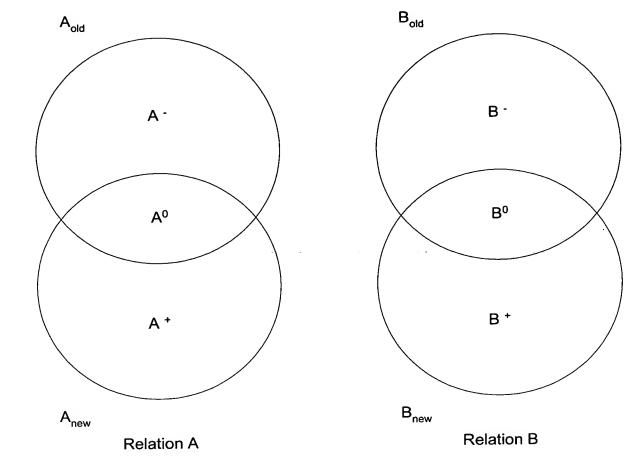
DB poll requests/results

Figure 6

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7-1

7-3

```
select *
from R2
where R2.b >50
```

```
select *
from R1
where R1.a < 100
```

```
select *
from R1, R2
where R1.a > R2.a
```

```
select *
from R1, R3
where R1.c = R3.c
```

7-2

7-4

```
select *
from R1, R2
where    R1.a > R2.a and
         R1.a < 100 and
         R2.b >50
```

```
select *
from R1, R2, R3
where    R1.a > R2.a and
         R1.c = R3.c
```

7-5

```
select *
from R1, R2, R3
where    R1.a > R2.a and
         R1.a < 100 and
         R1.c = R3.c
```

Figure 7

8-1

8-3

```
select *
from R2
where R2.b >50
```

```
select *
from R1
where R1.a < 100
```

```
select *
from R1, R2
where R1.a > R2.a
```

```
select *
from R1, R3
where R1.c = R3.c
```

8-2

8-4

```
select *
from R1, R2
where    R1.a > R2.a or
         R1.a < 100 or
         R2.b >50
```

```
select *
from R1, R2, R3
where    R1.a > R2.a or
         R1.c = R3.c
```

8-5

```
select *
from R1, R2, R3
where    R1.a > R2.a or
         R1.a < 100 or
         R1.c = R3.c
```
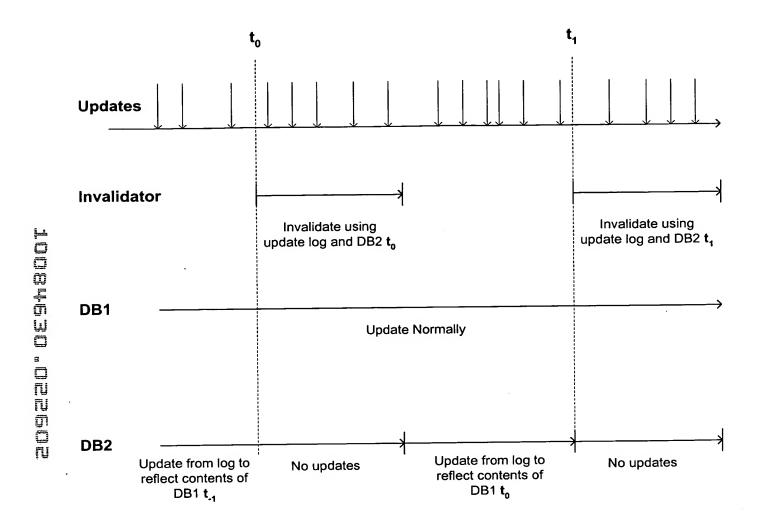
Figure 8

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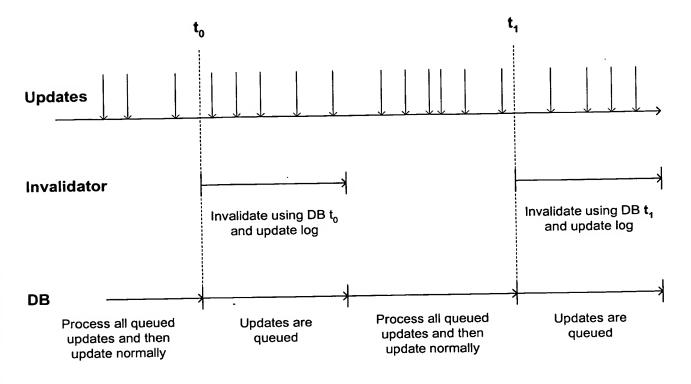FOLEY & LARDNER – (310) 277-2223
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Figure 9

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t_0 t_1

Updates

Invalidator

Invalidate using
update log and DB2 t_0

Invalidate using
update log and DB2 t_1

DB1

Update Normally

DB2

Update from log to
reflect contents of
DB1 t_{-1}

No updates

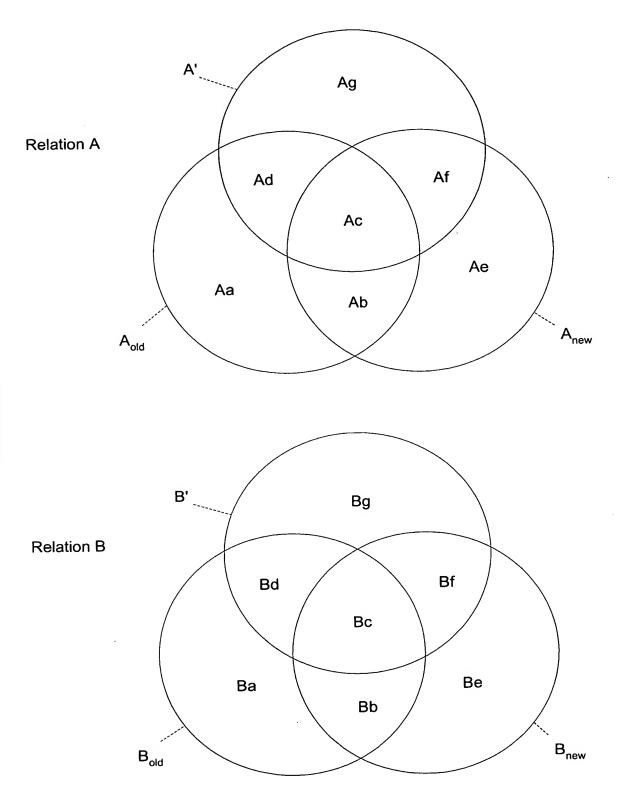Update from log to
reflect contents of
DB1 t_0

No updates

Figure 10

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Updates

Invalidator

t_0
Invalidate using DB t_0
and update log

t_1
Invalidate using DB t_1
and update log

DB

Process all queued
updates and then
update normally

Updates are
queued

Process all queued
updates and then
update normally

Updates are
queued

Figure 11

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Relation A

A'

Ag

Ad   Af

Ac

Ae

Aa   Ab

A_{old} A_{new}

Relation B

B'

Bg

Bd   Bf

Bc

Ba   Be

Bb

B_{old} B_{new}

Figure 12

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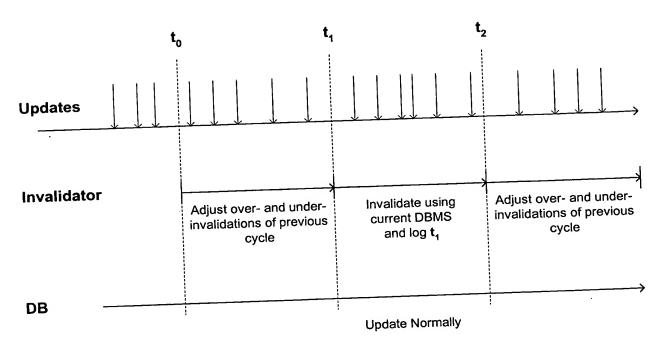FOLEY & LARDNER – (310) 277-2223
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Figure 13